

Technical Report 1210

Foundations of Military Pilot Selection Systems: World War I

Diane L. Damos

Damos Aviation Services, Inc.

September 2007



**United States Army Research Institute
for the Behavioral and Social Sciences**

20071204227

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REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) September 2007		2. REPORT TYPE Final		3. DATES COVERED (from. . . to) May 2005-May 2006	
4. TITLE AND SUBTITLE Foundations of Military Pilot Selection Systems: World War I				5a. CONTRACT OR GRANT NUMBER DASW01-03-D-0016	
				5b. PROGRAM ELEMENT NUMBER 622785	
6. AUTHOR(S) Diane L. Damos (Damos Aviation Services, Inc.)				5c. PROJECT NUMBER A790	
				5d. TASK NUMBER 351	
				5e. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Damos Aviation Services, Inc. 5250 Grand Ave, Suite 12, PMB 124 Gurnee, IL 600314				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral Sciences ATTN: DAPE-ARI-IR 2511 Jefferson Davis Highway Arlington, VA 22202-3926				10. MONITOR ACRONYM ARI-RWARU	
				11. MONITOR REPORT NUMBER Technical Report 1210	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES: Contracting Officer's Representative and subject matter POC: Dr. William Howse					
14. ABSTRACT (Maximum 200 words): This report describes the development of the U.S. Army pilot selection system beginning in World War I. It starts with a review of aviation in the United States up to 1917. The phases of flight training then are described with the associated failure and fatality rates. Some cost estimates for each phase also are provided. Finally, the pilot selection system itself is described. Because the selection system was revised over time, the early system (administered from May, 1917 to February, 1918) is described first, followed by the revised system (administered from March, 1918 to November, 1918). Additions to the initial battery are described, as are the tests that were under development at the time of the Armistice.					
15. SUBJECT TERMS pilot; Army aviator; selection; ab initio; World War I					
SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT Unlimited	20. NUMBER OF PAGES 19	21. RESPONSIBLE PERSON Ellen Kinzer Technical Publication Specialist (703) 602-8047
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified			

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September 2007

Army Project Number
633007A792

Personnel, Performance
and Training

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FOUNDATIONS OF MILITARY PILOT SELECTION SYSTEMS: WORLD WAR I

EXECUTIVE SUMMARY

Research Requirement:

Pilot selection has a long history in the United States military beginning with World War I. Reports dealing with this early period have become increasingly difficult to obtain, and recent literature reviews have not addressed this period in any depth. As a result, some individuals involved in pilot selection question the usefulness of instruments and procedures that have been effective for over 90 years.

Procedure:

This report describes the development of the U.S. Army pilot selection system beginning in World War I. It starts with a review of aviation in the United States up to 1917. The phases of flight training then are described with the associated failure and fatality rates. Some cost estimates for each phase also are provided. Finally, the pilot selection system itself is described. Because the selection system was revised over time, the early system (administered from May, 1917 to February, 1918) is described first, followed by the revised system (administered from March, 1918 to November, 1918).

Findings:

The development of the pilot selection system from early 1917 to late 1918 was driven by the need to reduce training costs. The early system did not adequately identify individuals who could not pass flight training or required inordinate amounts of time to do so. An intelligence test and an expanded survey of the applicant's athletic interests were introduced in order to reduce training costs. Tests of tolerance to hypoxia and auditory reaction time were also approved but not implemented before the Armistice. By mid-1918 investigators recognized that daily flight grades were influenced by factors other than flying skills, often lacked sufficient variance to be used as criteria, and suffered from poor interrater reliability.

Utilization and Dissemination of Findings:

The primary impetus for improving pilot selection systems was, and still is, a reduction in training costs. Intelligence tests and measures of athletic interest have proven their worth over 90 years and need to be retained in pilot selection batteries. The development of good criterion measures remains as much a priority today as it was, almost a century ago.

FOUNDATIONS OF MILITARY PILOT SELECTION SYSTEMS: WORLD WAR I

CONTENTS

INTRODUCTION	1
Limitations of the Current Report.....	1
Background	2
STAGES OF TRAINING	3
Ground school	3
Preliminary Training.....	3
Advanced Flight Training.....	4
Mission-Specific Training	4
FAILURE AND FATALITY RATES	5
Ground School	5
Preliminary Training.....	5
Advanced Training.....	6
Mission-Specific Training	6
COSTS OF FLIGHT TRAINING	7
SELECTION.....	8
Selection to 1917.....	8
May, 1917-February, 1918	8
February, 1918	9
March, 1918-November, 1918.....	10
SUMMARY	11
REFERENCES	13

FOUNDATIONS OF MILITARY PILOT SELECTION SYSTEMS: WORLD WAR I

Introduction

Many reviews of pilot selection (Hunter & Burke, 1995; Koonce, 1984; North & Griffin, 1977; Turnball, 1992) begin with a short overview of the World War I efforts. The authors agree that the scientific basis for pilot selection began during this period. Because documents from World War I are often difficult to obtain, these reviews may leave the impression that the WW I efforts were unsystematic, narrowly focused, and superficial.

This report attempts to lay a foundation for understanding pilot selection in the U. S. Army during World War I. It describes the stages of pilot training and presents data pertaining to training costs. It describes in as much detail as possible the pilot selection tests that were used during World War I. The primary goal of this is to show that far more research and development occurred during World War I than has been previously recognized.

Limitations of the Current Report

Articles published between 1917 and approximately 1920 often were impossible to obtain. Consequently, several potentially important articles could not be included in this review. Because this paper is concerned only with pilot selection in the United States, it ignores all of the research and development conducted in other countries. Interested readers may consult Hoff and Fulton (1942) for an extensive bibliography on early pilot selection and assessment including articles published in Russian, Polish, German, Chinese, Italian, Spanish, Portuguese, and Japanese.

The available World War I training data are often confusing and apparently contradictory. As will be described below, all stages of flight training were conducted in both the United States and Europe throughout America's participation in World War I. Some of the European training was conducted by the Allies and some by the Americans. No documents were found indicating that the curricula were standardized among the Allies, and different training aircraft were used at different bases. Thus, failure rates and other measures of training performance may be affected by the type of aircraft the students flew, the curriculum at the schools contributing data, and the English fluency of the instructors. To make matters more confusing, some training data are based on the period from the entry of the United States into the war on April 6, 1917 to the Armistice. Other data are accumulated from April, 1917 to the withdrawal of the Army from Europe in mid-May, 1919 (Gorrell, 1940). In some cases, it is impossible to determine the time period for the aggregation of the data.

The literature also demonstrates confusion between physiological and psychological phenomena. For example, sensitivity to tilt and to rotation sometimes were seen as psychological rather than strictly physiological phenomena. Selection tests involving physiological and medical factors were separated as much as possible from cognitive and personality tests in this review and are not discussed in the present report. The sole exception is the hypoxia tolerance test, which was seen partially as a reflection of psychological factors rather

than strictly physiological factors. Modern psychological terminology is used whenever possible in this report, to describe topics concerning cognition, intelligence, and personality.

Background

It is necessary to understand the state of aviation in the United States prior to its entry into World War I, in order to understand pilot selection during this period. The United States had no airlines, no civil airports, and no civil pilots prior to 1917, and was ranked 14th internationally in terms of aviation. Between 1908 and the American entry into World War I, the Army received a total of 224 aircraft, none of which was a combat aircraft (Gorrell, 1940). By 1917, the Army had trained a total of 139 pilots, of which 26 were actually qualified aviators (Gorrell, 1940). The Army at that time had only two flying schools. Aircraft production facilities were extremely limited; the first American-made aircraft did not see service in Europe until August, 1918. Thus, America had little in terms of aircraft, production facilities, flying training schools, or pilots at the beginning of the war.

No documents were found describing flight training prior to 1917. In early 1917, the U.S. Army decided to adopt a modified version of the Canadian and British flying training programs. The U.S. version divided flight training into three consecutive stages: ground school, preliminary flying training, and advanced flying training. Mission-specific training (pursuit, day bomber, night bomber, observer) was added to the curriculum by December, 1917 and occurred after the cadet had successfully completed advanced training.

The Army was very successful at establishing ground schools and flying training schools quickly. The first six ground schools in the U.S. were opened on May 21, 1917, approximately six weeks after the declaration of war (Gorrell, 1940). The last two were opened in July, 1917. By May 1918, the United States had established 25 flying schools in the United States and 16 in Europe.

At the beginning of the war, the Army entered into agreements with the Allies for flying training because of its lack of training facilities, experienced instructors, and aircraft. Consequently, American cadets were taught to fly using Allied instructors, aircraft, and training curricula. These arrangements continued throughout the war but apparently were of increasingly less use to the Army. Because the Army established American ground schools very quickly, only one agreement was reached for ground school training in Europe. This agreement was with the British and resulted in fewer than 500 Americans attending the school.

Gorrell (1940) notes that only 1791 cadets were sent directly to Europe for preliminary training versus 15,627 who were sent to bases in the continental U.S. Indeed, the proportion of cadets sent to Europe for preliminary flying training appears to have decreased over time although the absolute number remained relatively constant.

Because the Army initially had no combat aircraft, all advanced training had to be conducted in Europe. Initially, the instructors were Allies. Gradually, as the Americans gained combat experience, the Allied instructors were replaced with Americans. Some documents

indicate that the training was self paced and that the curriculum varied from school to school. Mission-specific training varied among the specialties.

The Armistice was declared on Nov. 11, 1918. Flight training in Europe continued until March 5, 1919. Although the United States was only in the war approximately 19 months, the innovations were truly amazing. By November, 1918, the United States could produce 23,000 aircraft per year. The horsepower of the aircraft engines increased from 150 to 300 with a 500 horsepower engine under development at the end of the war. The 41 flying schools that had been established cost over \$100 million in 1918 dollars to build, maintain, and operate (Gorrell, 1940).

Stages of Training

Pilot selection systems typically are evaluated in terms of performance on operational criteria, failure rates during training, and training costs. For the U.S. Army World War I pilot selection system, no documentation was found linking selection variables to operational criteria, such as number of aircraft shot down in air-to-air combat or number of reconnaissance missions flown. Consequently, all evaluations of the selection system must use criteria from each of the training phases. Although the data are not complete, it is possible to obtain some estimates of failure rates at each training stage. Limited data on training system costs and failure costs also are available and will be discussed in subsequent sections.

According to Gorrell (1940), both the Allies and the initial American experience indicated that it took about 90 hr of flying time and about 6 months to produce a pilot ready to fly at the front. These figures include preliminary, advanced, and mission-specific training. Gorrell does not indicate if the 6 months included ground school training.

Ground school

Students in modern military flight training often begin flying during the ground school phase of their program. In contrast, during World War I ground school training did not include any flight time. The U.S. Army ground schools were all established at colleges and universities and were taught by university faculty (Morin, 1997). The curriculum was taken from the Royal Flying Corps (Morin, 1997) and initially required 8 weeks. Sometime later, the ground school was expanded to 12 weeks. The extent to which the grading at these ground schools was standardized is not known. Morin (1997) notes that the Army decided to keep the failure rate high in ground school, the least expensive stage of training, to eliminate as many cadets as possible who would prove to be unsuccessful. This statement implies that the ground school was believed to have predictive validity to success in flight training. No evidence to support this belief was found. It also implies that the Army was concerned with the cost involved with pilot training and was seeking ways to contain the costs.

Preliminary Training

If the cadet passed ground school, he was sent to a flying training school and began preliminary flight training. Preliminary flight training in the United States lasted 6 to 8 weeks. Typically, cadets received 30 to 50 hr of flight instruction. This training stage apparently was at

least partially proficiency based. Consequently, cadets took varying amounts of time to complete the program and received different amounts of flying time (Morin, 1997). Cadet classes had varying mean total flight times, which may be related to individual differences in aptitude or to the training aircraft used at specific flying training schools. Based on 1600 cadets trained in the United States, Henmon (1919) states that the mean flight hours to complete preliminary training was "well below 50." This average apparently applies to data collected through June, 1918. Students were expected to solo after 3 to 4 hr of training; 6 hours without a solo flight was considered grounds for elimination in some schools (Morin, 1997).

Little information is available on the preliminary flying training conducted in Europe by the Allies or by the U.S. Army. Morin (1997) indicates that the British had developed a dual-control aircraft, which led to faster learning. Students soloed after 3 to 4 hr of flight time. The average total time to complete primary training in a British school was 8 hr. However, unlike the American system, a cadet was not considered to be an aviator until he had passed advanced training (Morin, 1997). By July 1, 1918 the American forces in Europe ended preliminary training and only conducted advanced and mission-specific training (Toulmin, 1927).

Advanced Flight Training

After graduation from preliminary flight training, most cadets were sent to advanced training in Europe, which began in late September, 1917. Advanced training familiarized the pilot with combat aircraft in contrast to training aircraft and taught more advanced aerobatic maneuvers. No documents were located describing the curriculum or the length of training. Gorrell (1940) provides one table indicating that some advanced training was conducted in the United States in 1918 but not in 1919.

Mission-Specific Training

At the end of advanced training, the pilot was assigned to a specific type of aircraft and mission (pursuit, day bomber, night bomber, observation). Several accounts hint that students were assigned to missions based on their performance in advanced training, but no policy papers could be located confirming this assignment strategy. Mission-specific training was designed to train specialized flying skills as well as skills that were unique to each type of training, such as gunnery for pursuit pilots and targeting for bomber pilots. By the summer of 1918, some mission-specific training had begun in the United States, but the war was over by the time the first U.S. trained pilot arrived in Europe (Morin, 1997).

Pursuit, day bombardment, and night bombardment training began on November 1, 1917 in Europe (Toulmin, 1927). Observation training did not begin until July 1, 1918. No documents were located describing the curricula or the length of training for any of the specialties.

Morin (1997) indicated that pursuit pilots were taught aerobatic maneuvers used in combat and formation flying. They also were taught dogfighting. Toulmin (1927) indicates that after flying training, pursuit pilots were sent to a special base to be trained in gunnery. This training lasted 10 to 14 days according to Toulmin and 4 weeks according to Mourrin. Toulmin shows the first class in gunnery beginning on December 28, 1917. This date implies that pursuit

training required about 7 weeks. Toulmin also indicates that pursuit pilots had to train in at least six different types of aircraft before completing the pursuit course. The need to fly so many aircraft was caused by a shortage of appropriate training aircraft. Toulmin complains that coordinating pursuit training was difficult and that the entire training process occasionally came to a complete halt, apparently because of aircraft problems.

Some of the information on bombing training provided by Toulmin is contradictory. He gives two different dates for the beginning of night bombing training: November 1, 1917 and September, 1918. Both of these dates refer to training conducted in England. Toulmin indicates that the training was delayed because of the lack of appropriate aircraft. He also indicates that day bombardment training was conducted in the United States, but that few pilots graduated from these schools and that all of these pilots had to be re-trained in Europe.

Failure and Fatality Rates

Ground School

The available literature produced two different estimates of the failure rate in ground school. According to Henmon (1919), 15% of cadets failed ground school and were eliminated from flight training. Henmon's estimate appears to be based only on training records from 1917. Gorrell (1940) indicates that the ground schools in the U.S. accepted 22,689 students from May 21, 1917 until the Armistice, of which 17,540 (77.3%) graduated. The 22.7% who did not complete ground school consisted of cadets who transferred to other assignments, failed training, or were discharged because of the Armistice. Gorrell provides no other data that allow the training failure rate to be separated from the transfer and discharge rates. Thus, 15% is the best estimate for the actual failure rate in ground school.

Preliminary Training

Henmon (1919) is the only source dealing strictly with failure rates in preliminary training for U.S.-trained cadets. Henmon estimates that at least 6% failed flying training for lack of aptitude but does not mention the time period used to make this estimate. However, Henmon provides data from Kelly Field, a training school in the United States, showing a failure rate of 6.7% (55 failures for lack of aptitude out of 824 cadets). These data appear to reflect all cadets trained at Kelly Field to June 1, 1918. Henmon (p. 104) notes that at least half of the "physical disability or incapacity" discharges were actually for lack of aptitude. Addition of 50% of the physical disability discharges (11 cadets) to the lack-of-aptitude failures results in a failure rate of 7.3%. A report published by the Director of Military Aeronautics and cited by Henmon appears to have data through June 30, 1918 and shows that approximately 7.4% of the cadets were eliminated from training for lack of aptitude. This reference does not indicate if the data were obtained just from U.S. flying schools or included data from European flying schools.

Morin (1997) is the only source dealing with preliminary training in Europe. He gives data for a school built by the Italian government specifically to train American pilots. The instructors were Italians, but the administration was under control of the U.S. Army. Again, like

U.S. training schools, solo was expected after 3 to 4 hr of flight training in a dual-control aircraft. This school graduated 406 out of 450 cadets, for a failure rate of 9.8%.

Gorrell (1940) provides data on the average flight time per fatality during preliminary training for Allied pilots. He shows an average time of 2887 hours of flight time per fatality for American pilots trained in France versus 2680 hr for French pilots. For Americans trained in the United States, the comparable figures are 2973 hr in 1918 and 1309 hr in 1919. The reason for the sharp increase in the fatality rate in 1919 is not known.

Advanced Training

No data were found for failures in advanced training although students did fail this phase of training. However, unlike preliminary training, advanced training had a significant fatality rate. For example, Gorrell (1940) records that 34 out of 542 (6.3%) Americans were killed in flight training in British schools. This figure represents all advanced training until March 5, 1919 and apparently does not include those who survived a crash but were hospitalized. Figures for Issodun (a large U.S. training base in France) can be used to give an approximation to the fatality rate for advanced training in U.S. schools. Gorrell shows a total of 1839 graduates of the advanced course to November 11, 1918. He also shows 25 fatalities in the advanced course to March 5, 1919, which gives approximately a 1% fatality rate. Toulmin (1927) indicates that many of the fatalities were the result of air-to-air collisions near the airfields.

Gorrell also provides time between fatalities for comparison purposes. Unfortunately, he shows the average flight time per fatality for Americans trained in Europe as 1487 hr in one chart (pg 17) and as 936 hr in the body of report (pg 22). It is impossible to determine which of these numbers is correct. For comparison purposes, the comparable flight times for the British and Italian pilots were 573 and 747 hr, respectively. Thus, the American fatality rate compares favorably to that of the Allies.

Mission-Specific Training

Only Toulmin (1927) provides any data on mission-specific training. His data are limited to August, September, and October, 1918 and include only pilots trained by the U.S. Army in Europe. Several new mission-specific training schools had been started during the summer of 1918 and the capacity of the existing schools had been expanded. Thus, his data represent the largest number of cases per month for the war. Toulmin, however, only presents the number of pilots who began training and the number who successfully completed training. Thus, true failures, fatalities, and sickness/hospitalizations are included in the number who failed to complete training. Toulmin does not discuss transfers to other specialties at any point, and the data do not include early terminations because of the Armistice. The non-completion rates were 47.3%, 33.6%, and 6.1% for pursuit, observer, and bomber (day and night), respectively.

No data for overall fatality rates were found. Nevertheless, fatality data were located for Issodun for its pursuit training curriculum. Gorrell shows 829 graduates of the pursuit course at Issodun to November 11, 1918 with 46 fatalities to March 5, 1919. These numbers give approximately a 5.3% fatality rate for the pursuit course. The comparable figure for observation

training was 443 graduates with 6 fatalities (1.3% fatality rate). Gorrell gives flight time per fatality for each type of mission-specific training. He shows 833, 605, 1096, and 359 hr for pursuit, observation, day bomber, and night bomber, respectively. Thus, although the pursuit specialty was the equivalent of the modern fighter pilot, the night bomber trainee had the highest fatality rate, which may be attributed to poor aircraft instrumentation. The lack of appreciation for visual illusions may also have contributed to the high fatality rate. These numbers include training conducted by the Allies as well as training conducted by the U.S. Army in Europe.

Costs of Flight Training

The major goal of any selection system is to identify the best applicants for the job. As noted earlier, the only criteria mentioned for the U.S. Army pilot selection system are training criteria because, like its modern counterparts, the Army was trying to minimize the cost of pilot training. Henmon (1919, p. 104) provides data on training failures and costs and then states "the need for improvement in methods for selecting flyers was and is very great." The most appropriate analysis of the World War I selection data would divide the 20 months of U.S. involvement in World War I into periods defined by the introduction of new selection tests. The training failure rates, fatality rates, and cost data then would be presented for each period. Currently, no records permit the data to be divided in this manner; and some information, such as fatality costs, is not available. Therefore, this document will discuss some of the unusual aspects of World War I flight training that made this training expensive.

Perhaps the most unusual feature of World War I training was the accident rate. The cost of destroyed and damaged training aircraft and the resulting fatalities was unusually high. Although modern military flight training schools experience a few accidents, in World War I, training accidents were common. Accidents during initial solo flights seemed unremarkable and both Rippon and Manuel (1918) and Henmon (1919) comment on aircraft losses and fatalities. The need for replacement aircraft, repair costs, and fatality-related costs clearly added to flight training costs.

The second unusual feature concerns extra training. Because of manpower demands during a war, military training organizations often will provide extra training to marginal students to increase the probability that they pass. This extra training increases the overall training costs and does not ensure that the student passes the course or eventually becomes a combat pilot; the extra training may simply delay the failure. In modern U.S. military training schools, the need for extra training is carefully scrutinized and limited. During World War I, however, the Army provided excessive extra training to marginal students. Henmon (1919) observes that at Kelly Field one cadet was given 106 flight hr to complete the course, whereas another received 94 hr. Another cadet got 55 hr of flight time and wrecked 5 aircraft before he was failed out of the program. These numbers should be compared to average completion times ranging from 30 to 50 hr (Henmon, 1919).

Flight failures add to the overall training costs. Henmon (1919) reports that a total of 74 cadets out of 824 at Kelly Field failed to complete training. Henmon estimates these 74 cadets wasted 1400 hr of flying time and destroyed 30 aircraft. He states that preliminary flight training cost \$120 per hr but was unsure if this figure included the cost of damaged and destroyed

aircraft. Assuming that the estimate includes aircraft replacement and repair, the total cost of these 74 failures was a minimum of \$168,000 in 1919 dollars.

Gorrell (1940) indicates that the average cost of advanced and specialized training at a U.S. school in Europe (Issodun) was \$8693 per student in 1918 dollars. Again, this value appears to be an average, but Gorrell gives no information on how it was calculated. For comparable courses taught by the British in the U.K., the U.S. paid \$5000 per student.

Selection

Selection to 1917

The earliest pilot selection efforts were concerned with medical issues associated with flying. The first paper on aviation-related medical issues appeared in 1907 (Anderson, 1919), only 4 years after the Wright brothers' first flight. In 1910, the Germans developed special medical qualifications for pilots (Armstrong, 1943), followed by the Americans in 1912. According to Armstrong (1943) these standards were ignored during the early years of World War I with disastrous consequences. The Germans subsequently revised their standards and implemented the new version in 1915. By October, 1916, the Royal Flying Corps had established its medical selection board; France followed in 1917 (Anderson, 1919; Armstrong, 1943).

During this period, the aviation medical community realized that psychiatric factors affected flying performance. In 1914, Ovington, an American, published a letter in a medical journal entitled "The psychic factor in aviation."¹ By 1916, the Royal Air Corps had documented nervous breakdowns of cadets (Anderson, 1919). However, no systematic attempt was made to screen cadets for possible psychiatric problems until May, 1917.

May, 1917-February, 1918

The U.S. Army Air Services revised its medical examination and implemented the revised version, "Form 609," in May, 1917. The medical examination was comprehensive and not altered until after World War I (Anon., 1919). The U.S. Army clearly understood that careful medical selection of applicants decreased training costs (Anon., 1919). Consequently, the standards were rigorous: Armstrong (1943) indicates that 30.3% of the pilot applicants failed one or more parts of the medical examination.

Form 609 was the primary pilot selection instrument of World War I. From its inception, Form 609 contained many non-medical elements, which were administered and scored by Aviation Examining Boards. The few descriptions of the earliest version of Form 609 are particularly vague and brief (Henmon, 1919; Stratton, McComas, Coover, & Bagby, 1920). Stratton et al. refer to a "professional and mental examination" that was based upon "the candidate's written answers to a series of questions covering his parentage, education, business experience, athletic attainments, responsibilities placed upon him by others, military training...." Pilot candidates had to provide the Board with at least three letters of recommendation attesting

¹ No reference is given for this document by Anderson (1919).

to their moral character and credentials documenting their education. They also had to appear before an Aviation Examining Board for an oral examination.

No documents were located describing the professional, mental, and oral examinations in detail. The “mental examination” is particularly puzzling. Stratton et al. (1920) indicate that the mental examination was distinct from the psychiatric examination included in Form 609. The mental examination probably was not the Army Alpha test, which was not completed until July, 1917 (Gould, 1981). Although records indicate that the Alpha Test was administered at Army camps (Gould, 1981), no records show that it was administered by Aviation Examining Boards. Like the three examinations, no source for the biodata questions was found with the exception of the questions pertaining to athletic activities and interests, which were developed by E. L. Thorndike.

Henmon (1919) estimates that between 50 and 60% of the pilot applicants failed Form 609. Given that approximately 30% failed the medical portion, the non-medical portion accounted for significant attrition. Again, these estimates appear to cover all of 1917 and may include early 1918.

February, 1918

The Army stopped all pilot applicant examinations on February 9, 1918 because the number of successful pilot applicants waiting to begin training greatly exceeded the capacity of the training facilities. Applicant testing was never resumed because the Armistice was signed before the backlog of pilot applicants had been sufficiently reduced. The pilot selection literature dealing with the period from February to November, 1918 is vague but seems to imply that at least two selection tests that had been under development, the Mental Alertness Test and an expanded survey of athletic interests, were administered after February 9, 1918. However, there is no evidence that cadets who had passed an earlier version of Form 609 were eliminated because of their scores on either instrument. Because derivatives of both of these instruments are still in use today, their validation process should be examined as carefully as the record permits.

The information pertaining to the athletic survey is brief but relatively clear. Henmon (1919) implies that sometime prior to March, 1918, Thorndike found a positive correlation between success in flying training and athletic ability. Thorndike subsequently expanded the biodata section dealing with athletic activities and developed a new scoring key. Henmon indicates that the expanded version was adopted but gives no date for the adoption.

According to Henmon (1919), Thorndike also developed the Mental Alertness Test, which was an intelligence test. It was composed of 13 subtests assessing different aspects of intelligence, but no description of the subtests was found. Stratton et al. (1920) show that the test was strictly an addition to Form 609; it did not replace the mental, professional, oral, or psychiatric examination.

In a presentation given in December, 1918 and subsequently published, Thorndike (1919) reported that scores on the Mental Alertness Test correlated 0.50 with success in ground school. He contrasted this number with the 0.25 correlation between years of schooling and success in

ground school. Scores on the Mental Alertness Test also correlated 0.3 with flying performance and with ratings of general officer quality. Thorndike (1919) indicated that he had insufficient data to determine how well the Mental Alertness Test predicted operational performance.

Henmon (1919) seems to imply that the Mental Alertness Test had been validated and accepted for use prior to March, 1918. In contrast, Yerkes (1919) states that Thorndike began work on the Mental Alertness Test in August, 1918. This date seems unlikely unless the test was developed in a few weeks and administered immediately to cadets at the beginning of ground school. To produce the correlation with flying performance given above by December, the test also must have been administered immediately to cadets at the beginning of preliminary flight training. In such a case, only those cadets who successfully completed ground school took the test, and range restriction would have caused an underestimation of the correlation between test score and flying performance.

Further investigation will have to determine when the Mental Alertness Test was developed. Investigators recognized the need for better selection instruments during the summer of 1917 (Henmon, 1919). Why they felt the need for a complex intelligence test and how the subtests were selected needs to be established.

March, 1918-November, 1918

Several articles (e.g. Henmon, 1919; Stratton et al, 1920) imply that investigators assumed that pilot selection would resume as soon as the training facilities had cleared the backlog of cadets. Consequently, the Army continued research on pilot selection until the Armistice in November, 1918. Tests under consideration were administered either using a predictive validity or a concurrent validity approach. Investigators using the predictive validity approach administered the tests prior to the beginning of preliminary flight training or very early in flight training (Henmon, 1919) and then collected data on instructor ratings and success in flight training. None of the papers reviewed showed any appreciation of problems associated with range restriction; all of those tested had passed both Form 609 and ground school prior to testing. Investigators using the concurrent validity approach gave the tests to two groups of cadets. The first group was rated as performing very well in preliminary flight training. The second group was rated as performing very poorly or had failed flight training. Investigators then attempted to determine how well the test discriminated between the two groups.

Using both validity methods, Henmon (1919) identified five new tests that were approved in mid-1918 for inclusion in the pilot selection battery. Three of these tests—swaying, equilibrium reaction, and perception of tilt—now would probably be classified as medical tests of the inner ear. The fourth was a measure of the startle response and, again, probably would be seen today as a medical test. The fifth was a simple reaction time test using auditory stimuli. Because no new pilot applicants were being accepted, these five new selection tests were to be administered at ground schools. Henmon is vague about exactly when the cadets were to be tested. Logically, they should have been administered just before the cadet began ground school. However, by the time the testing facilities had been set up, the Armistice was declared, and the ground schools were disbanded.

By 1918, aircraft with service ceilings over 23,000 ft were in use. Because military aircraft had no supplementary oxygen, the Army wanted to identify individuals who could function at higher altitudes. Before pilot selection was suspended in February, 1918, the U.S. Army had intended to include a test of hypoxia tolerance in Form 609 but had not yet implemented the test. After March, 1918, the hypoxia test was changed to a classification test rather than a selection test.

Unlike the modern understanding of the effects of hypoxia on performance, investigators in World War I attributed some of the observed individual differences to psychiatric problems as well as to physiological differences. Armstrong (1943) indicates that the test was administered to all pilots stationed near branch laboratories (see Dunlap, 1918 for testing details). The exact point in training at which this test was administered and its effect on pilot assignments are unclear.

Summary

The development of the U.S. military aviation infrastructure during World War I was impressive. In approximately 20 months, the Army went from two flying schools to 25 and from 26 fully qualified pilots to over 16,000. The development of aircraft production facilities was equally impressive. The classic U.S. pilot training scheme of ground school, preliminary, and advanced training followed by mission-specific training was adopted at this time.

Before the beginning of the war, the only pilot selection tests were medical. Within six weeks after the declaration of war, the pilot selection battery had expanded to include biodata, including a survey of athletic interests, and a mental assessment. The relationship between athletic achievement and success in flying training was noted early and a detailed survey was developed to provide more information on a candidate's athletic interests. This relationship has continued to the present. The need for more in-depth assessment of the candidate's intelligence was also noted and an extensive intelligence test was added to the battery in 1918.

Tests involving reaction time were approved for inclusion in 1918. Again, reaction time tests have continued to be used in U.S. pilot selection except for a brief period from approximately 1960 to 1985, when the reliability of the testing apparatus was questioned. The need for assessment of vestibular function was also recognized during this period.

Changes to the selection system during World War I were clearly motivated by a desire to contain training costs, which included aircraft repair and replacement. The need for a standardized curriculum with a maximum number of flight hours per module does not appear to have been appreciated, which increased costs by allowing marginal students to continue too far into training. Cost containment at the advanced and mission-specific phases of training was clearly hampered by the early need to rely on the Allies for instructors and facilities and later, for training aircraft. Toulmin (1927) commented on the poor quality of the training aircraft, the large amount of repairs needed to maintain the aircraft, and the need to use different types of aircraft to maintain a flying schedule.

Perhaps more importantly, by the end of World War I, investigators made three observations that are still valid today, almost 90 years later. First, no one test can be used to predict success in flight training (Henmon; 1919; Stratton et al, 1920; Thorndike, 1919); many factors need to be assessed. Second, flying grades are frequently poor criteria because of the lack of variability in the scores (Johnson, 1920), poor interrater reliability, and because other factors, such as bearing as a military officer affect grades (Stratton et al, 1920). Third, late stage failures are disproportionately more expensive than early failures (Henmon, 1919).

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